Interim Progress Report

EXHIBIT "A"

Contract NAG8-293, Subcontract No. SUB93-101

USE OF PHOTOSTRESS TO ANALYZE BEHAVIOR OF AN AFT SKIRT TEST SPECIMEN

Submitted to

NASA/MSFC
through
The University of Alabama
in Huntsville
Huntsville, Alabama

Prepared by

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December 26, 1992 - July 26, 1993

NAG8-293

FNAS/Summer Faculty Fellowship Research Continuation Program

Entitled

Use of Photostress and Strain Gages to Analyze Behavior of Weldments

and

Use of Photostress and Strain Gages to Analyze Behavior of an Aft Skirt Test Specimen

SEMI - ANNUAL REPORT

December 26, 1992 - July 26, 1993

Submitted to

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

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INTRODUCTION

Previous work using Photostress on TIG welded, heat treated specimens of 2219-T87 parent material and 2319 weld material indicated that behavior of the joint can be highly irregular and non-uniform (1,2). Welded joints 1.40 inches thick exhibited a totally non-uniform behavior through the weld thickness with the "wide" side of the weld being much more ductile than the "narrow" side (see Figure 6). It is believed that this difference in behavior through the weld is, in part, caused by procedures used when laying the weld bead.

Joints similar to those tested in references 1 and 2 are an integral part of the aft skirt of the SRB of the shuttle. Since the ultimate safety factor for the lower portion of the weld is below the minimum required safety factor, a Photostress analysis of this lower portion will be conducted in the vicinity of the weld (see Figure 3). A test program using Photostress will be conducted in accordance with the project planning document entitled "Photostress Evaluation Requirements for AFT Skirt Test Article No. 4"(3).

PROGRESS TO DATE

With reference to identification of the "wide" and "narrow" sides of the weld mentioned above, Figure 6 indicates the surfaces so identified as well as the "through the weld" view of the 1.4" thick weld.

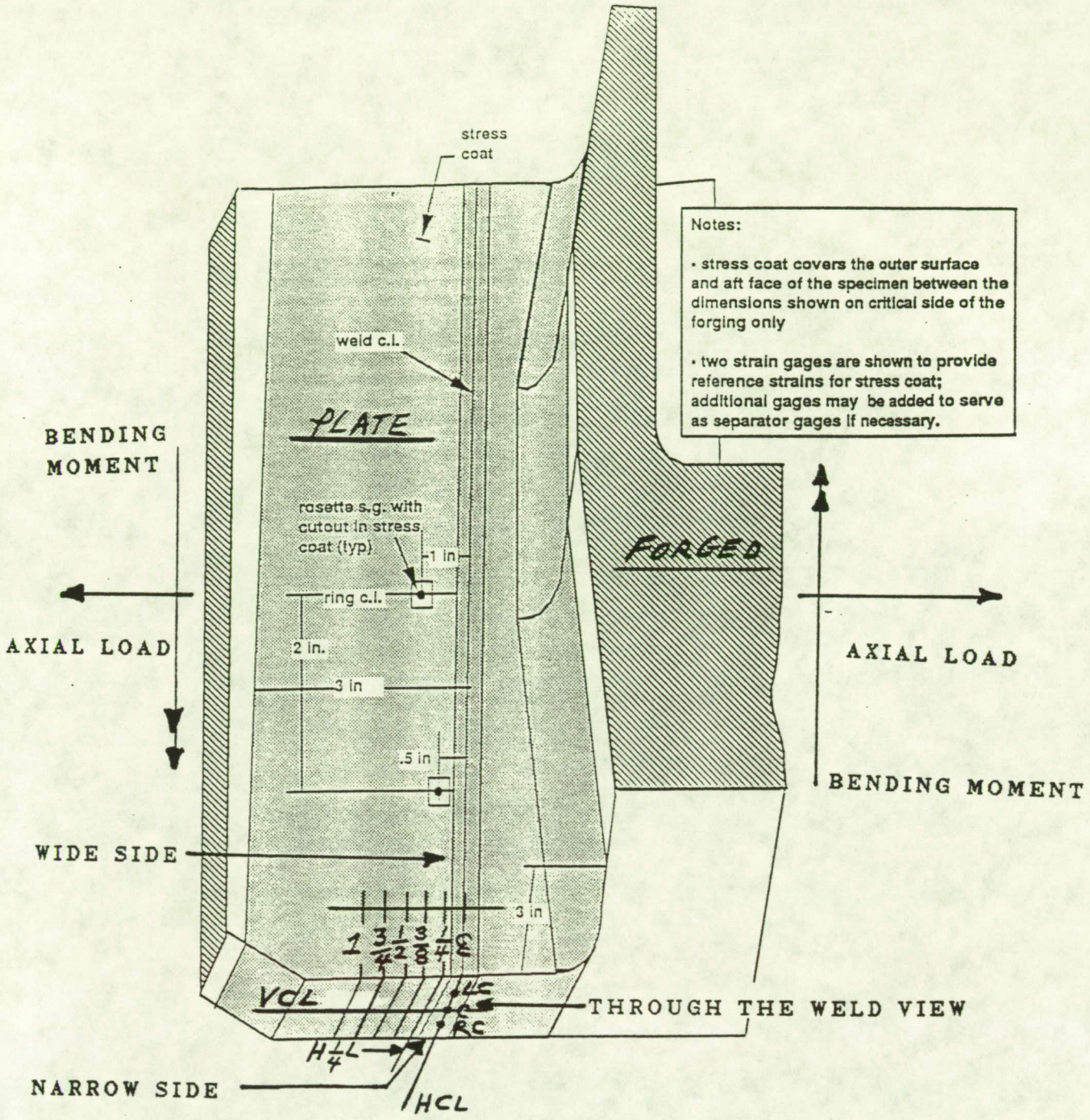

FIGURE 6 PHOTOELASTIC COATING IN TEST SPECIMEN NO. 4

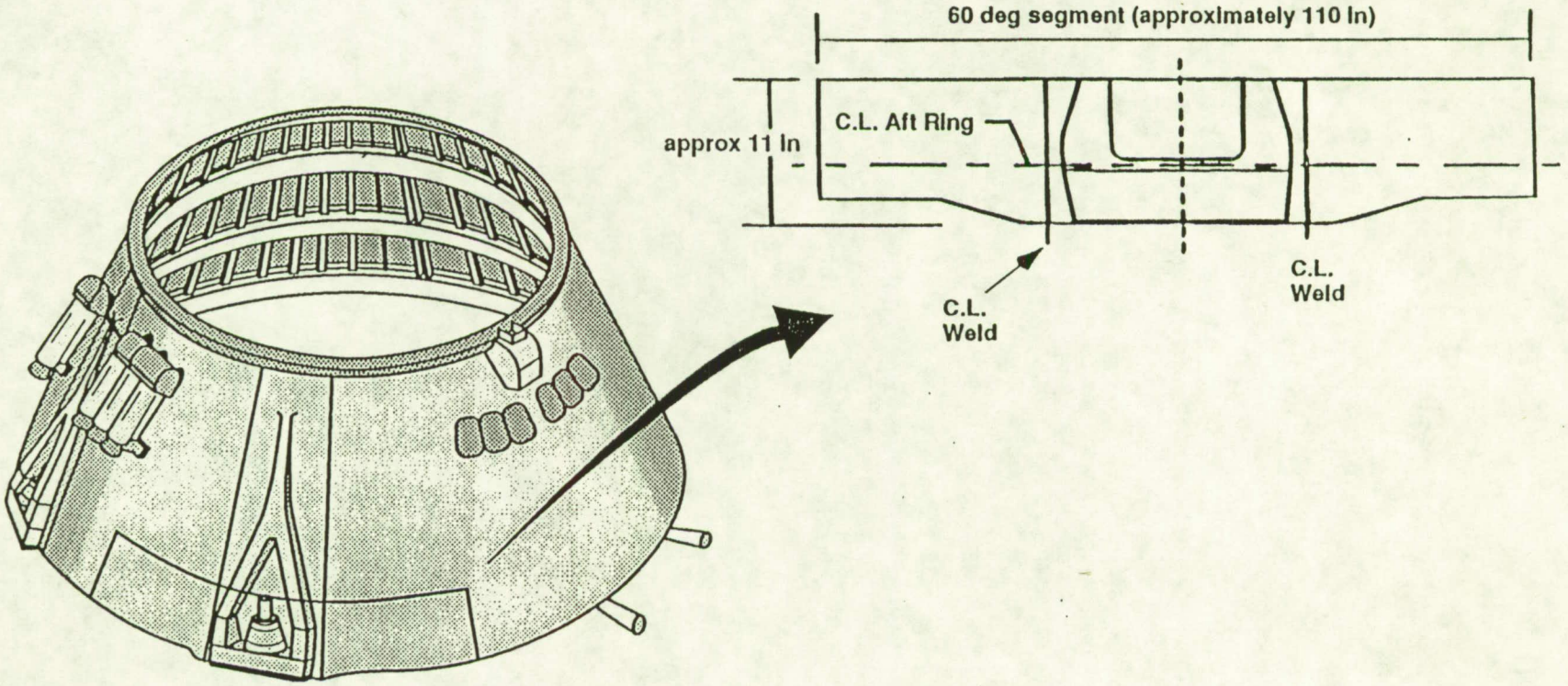

FIGURE 3 TEST SPECIMEN

A. Calculations indicate that the photoelastic coating used on the aft skirt should to be 0.067 inches thick for measurement of maximum shearing strains of $8,500 \times 10^{-6}$ within five fringe orders.

B. Correction factors for the photoelastic coating and stress separator gages have been calculated as 0.96 and 0.92 respectively.

C. A preliminary investigation of the critical region of the aft skirt has been conducted which included all steps required for the final investigation of the aft skirt to be received at MSFC in August or September, 1993. Pertinent information/results obtained from the preliminary investigation are listed in the following:

1. Photoelastic coatings were poured, contoured, and attached by NASA personnel to the aft skirt hold-down post as seen in Photos 1 and 2. The average thickness of the coating was 0.0731 inches with a standard deviation of 0.0043 inches. Within plus or minus two standard deviations, this variation produced an overall accuracy in measuring shearing strains of

$$\gamma_{reading} \pm 12\%.$$

For the test of the aft skirt during the Fall of 1993, it has been decided to order the contourable photoelastic coatings from Measurements Group in Raleigh, NC, to reduce the percent scatter in readings

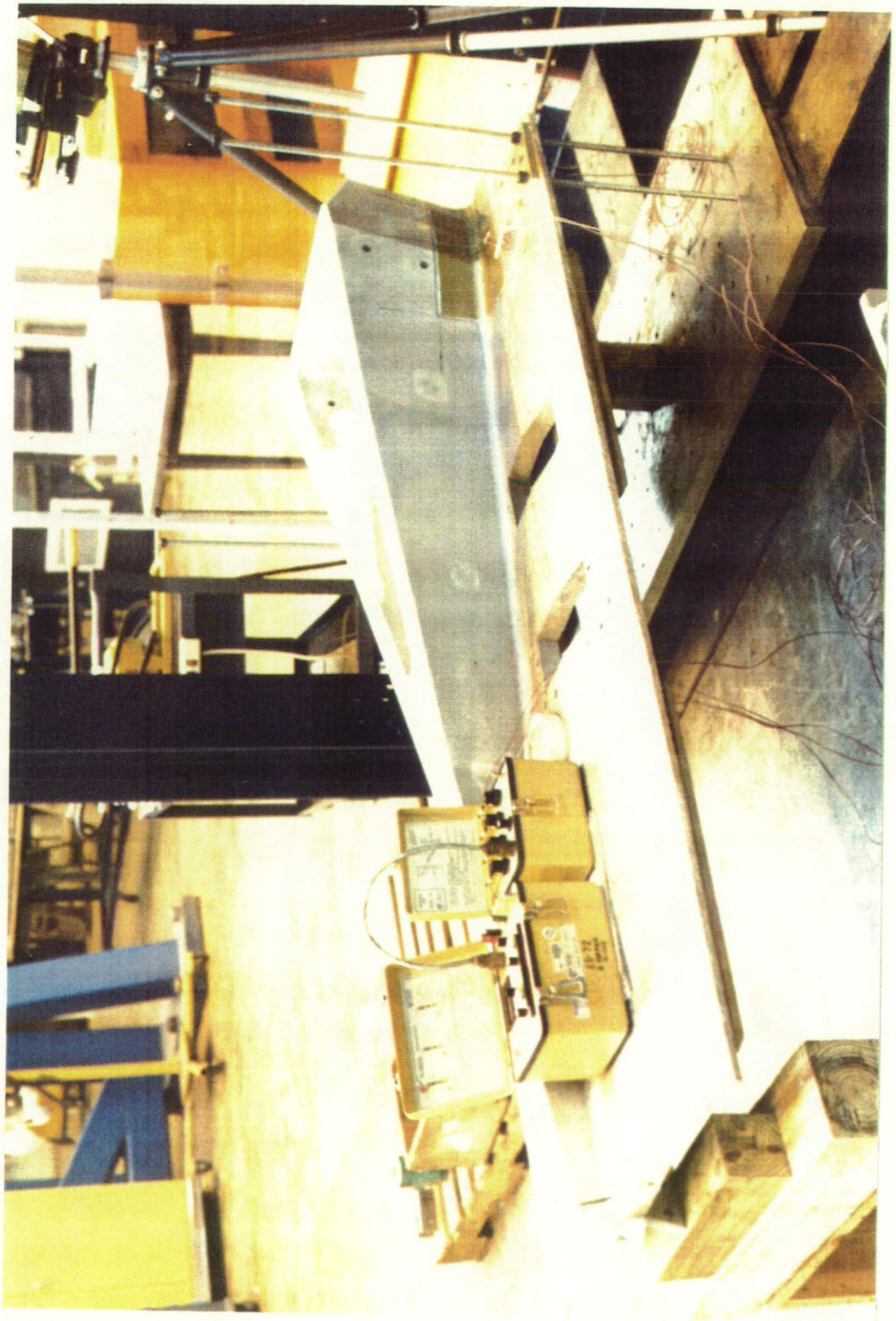

Photo 1. View of Hold-Down Post with Photoelastic Coating

ORIGINAL PAGE
COLOR PHOTOGRAPH

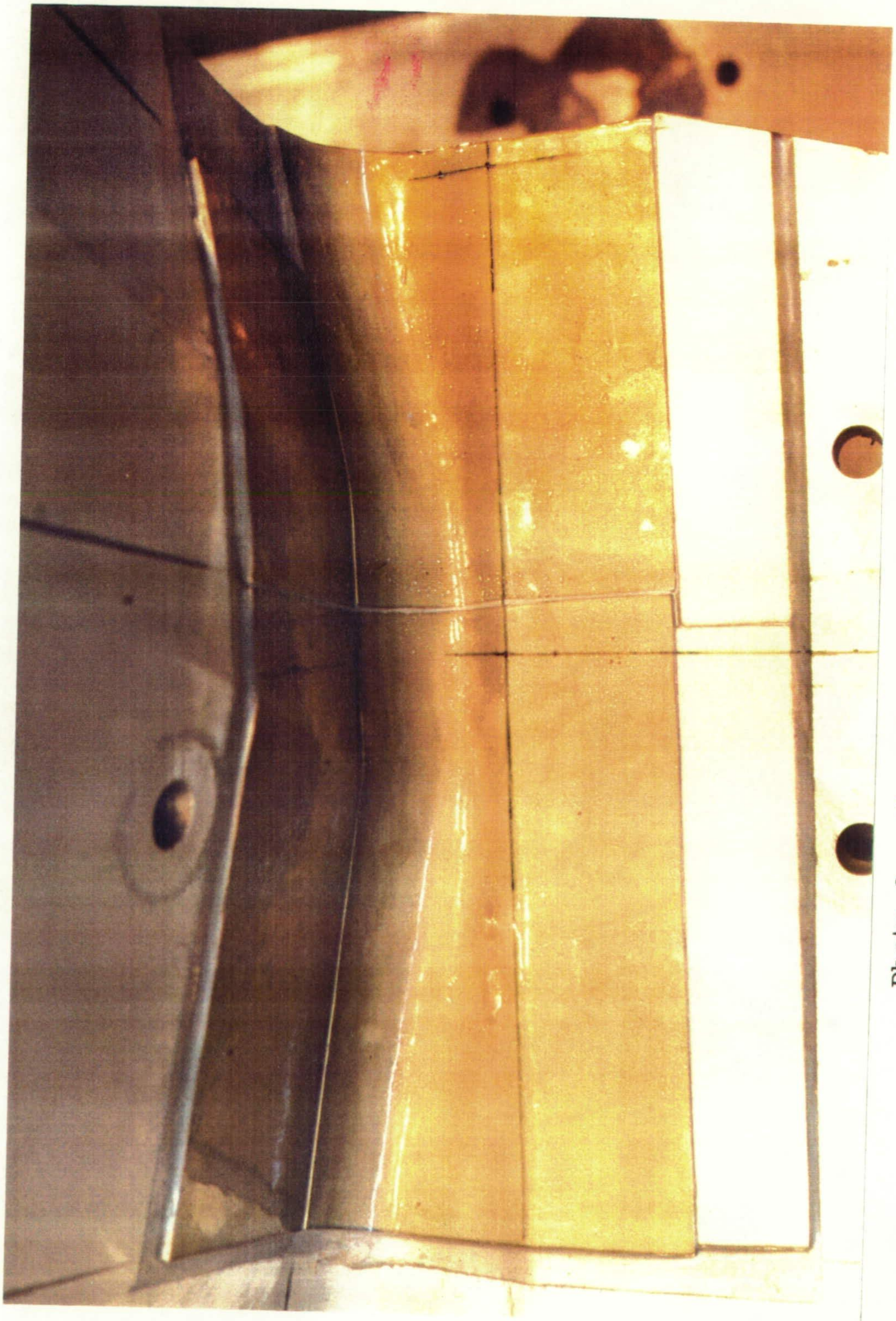

Photo 2. Close-Up of Photoelastic Coating

of shearing strain due to thickness variation of the coating to nearly zero.

Photo 1 shows the hold-down post with the photoelastic coating near the right end at the critical area and Photo 2 is a close-up of the coated critical area.

2. A grid network, approximating that which will be used during the Fall test of the aft skirt, can be seen in Photo 3. Sixty-four (64) points are identified for measurement of shearing strain including twelve (12) at which photostress separator gages will be used to separate the principal strains. (See Figure 3-1).

3. Photo 4 includes a series of fringe patterns produced when the hold-down post was loaded with a hydraulic jack in the manner seen in Figure 4. The force provided by the jack is given under each picture. One can clearly see the region of highest shearing strain between points 34 and 41 along the line one-half inch to the right of the centerline of the weld (points 18-30). Between points 34 and 41, the highest shearing strain of 1728×10^{-6} occurred at point 37. For the aft skirt test in the Fall, the highest shearing strain is expected to be approximately 4 to 5 times the value given here and will not necessarily be along the line including points 34 through 41.

Prior to receipt of the #4 aft skirt test specimen in the Fall of 1993, photoelastic coatings, adhesive, stress separator gages, and film will be ordered to provide for instrumentation of

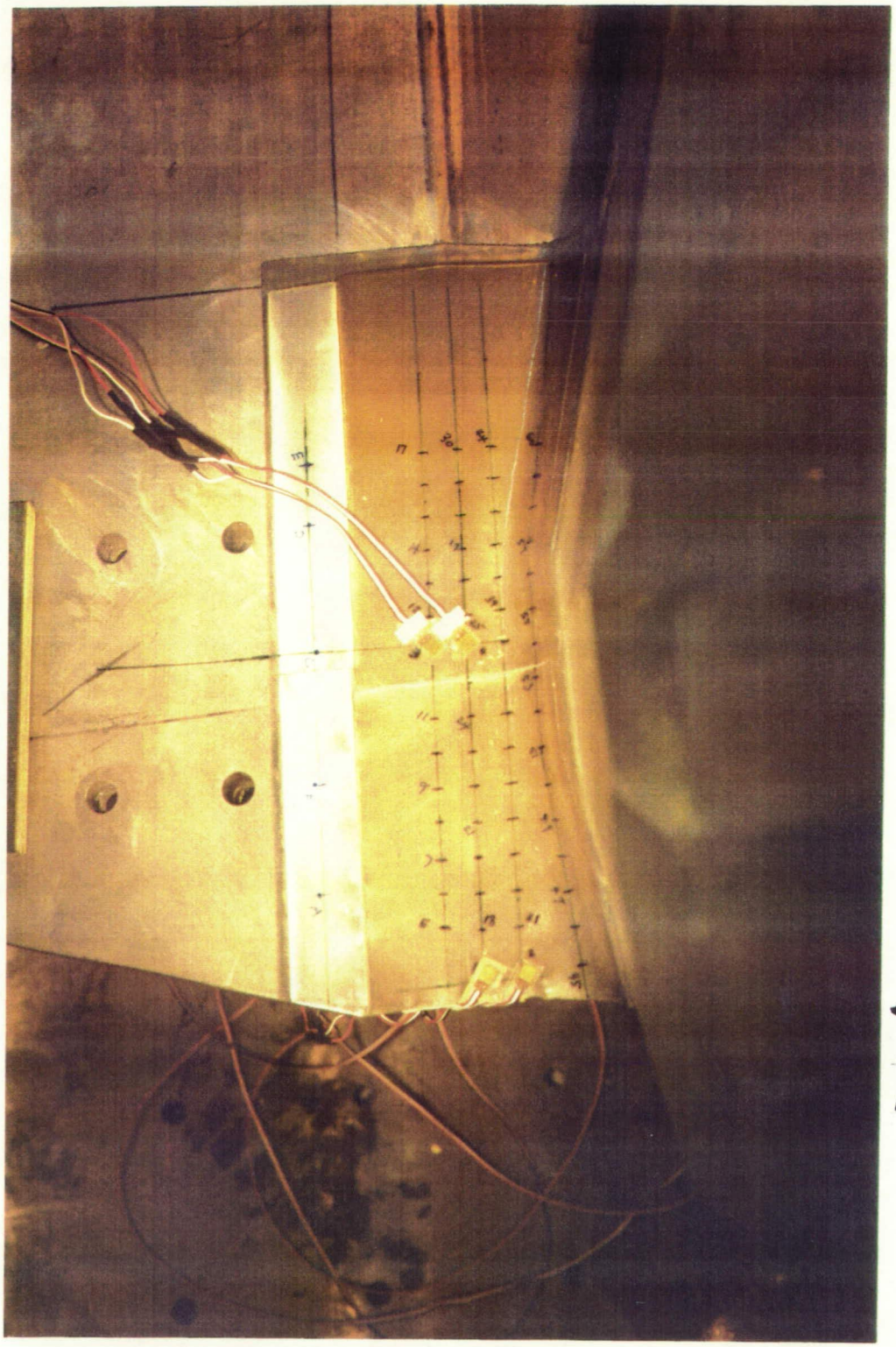

Photo 3. Top View of Photoelastic Coating Showing Grid Network and Four Stress Separator Gages

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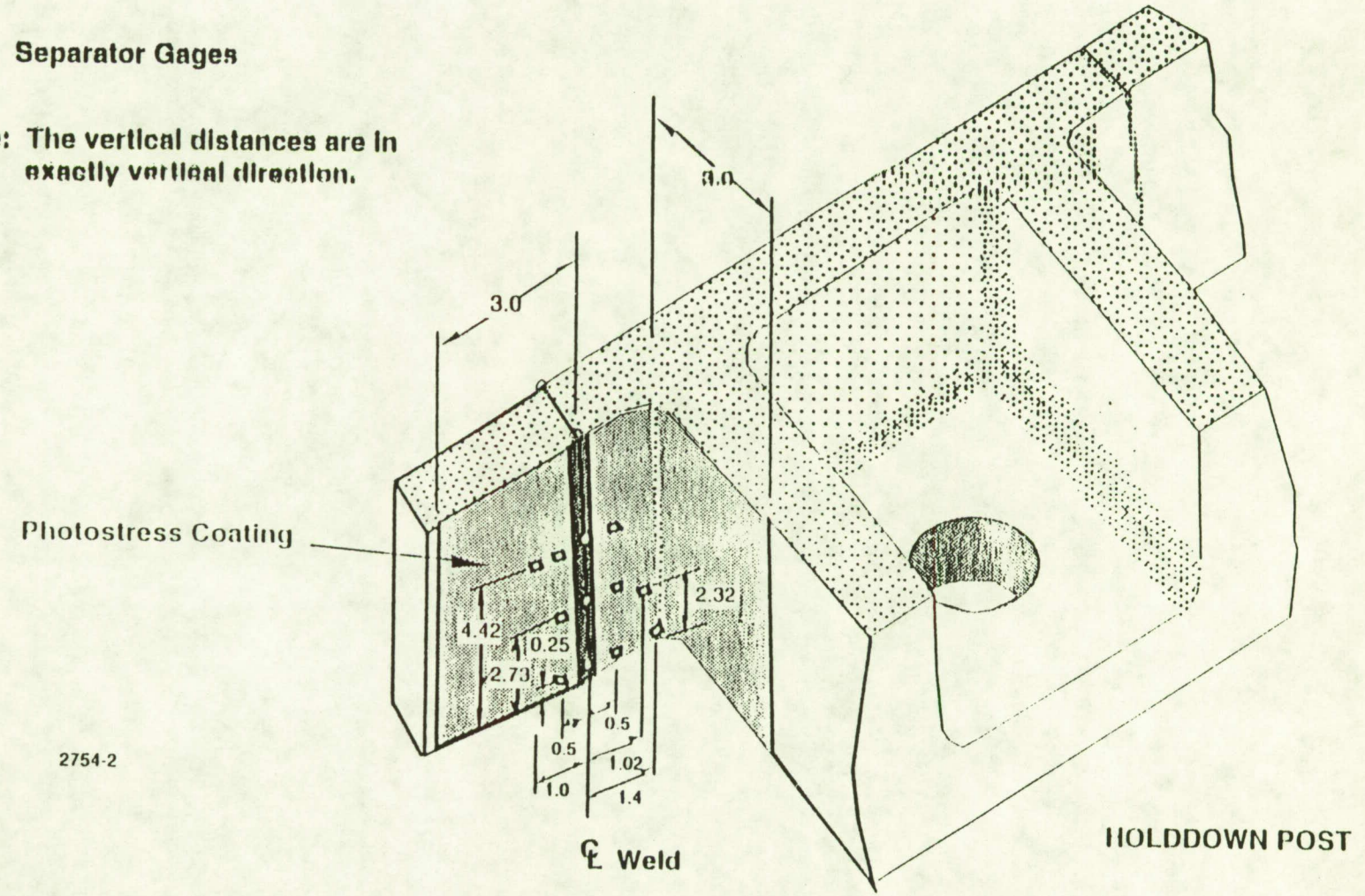
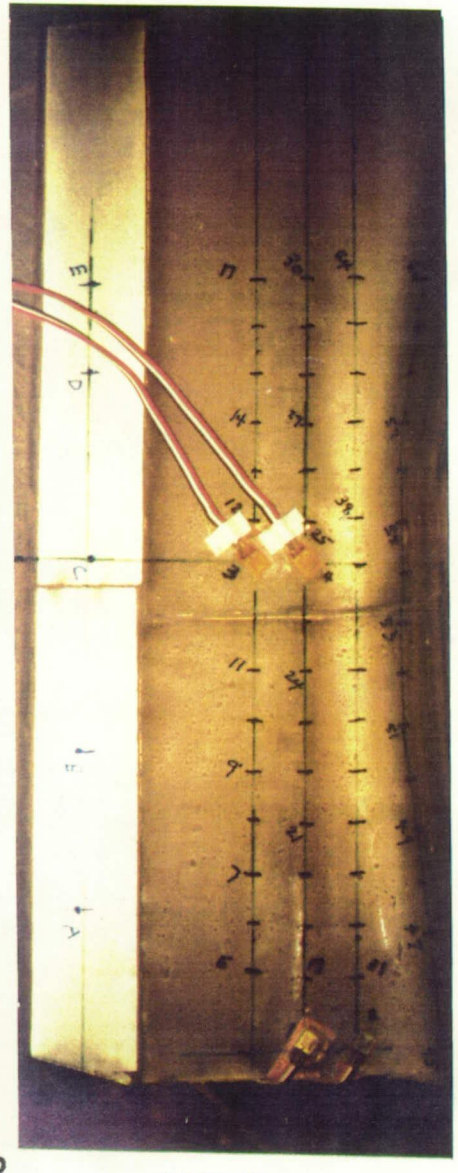
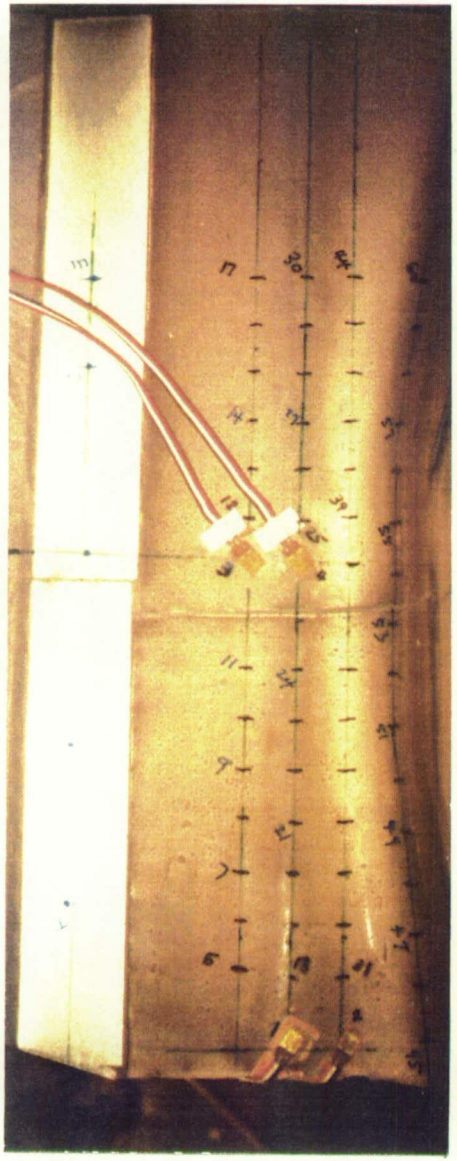


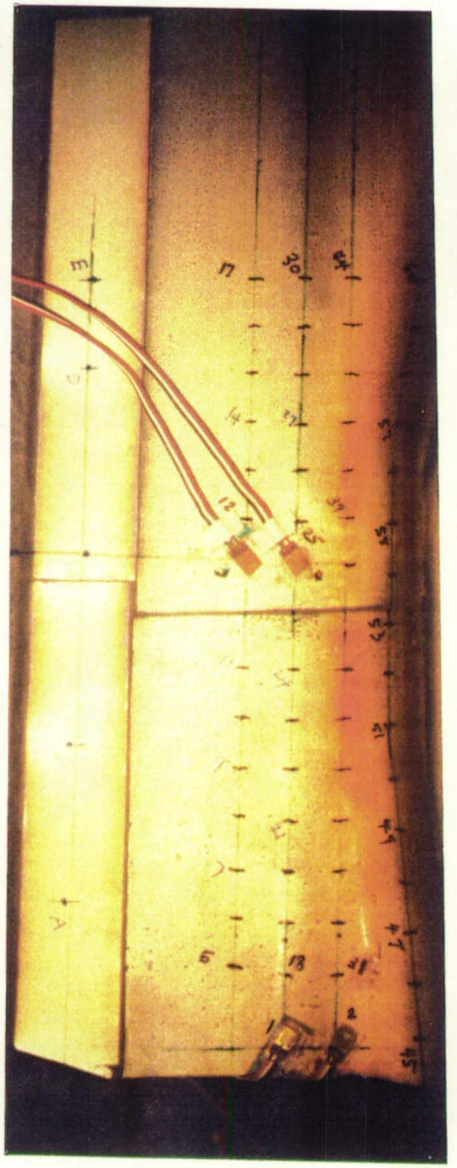
Figure 3-1 Areas with Photoelastic Coating and Separator Gages



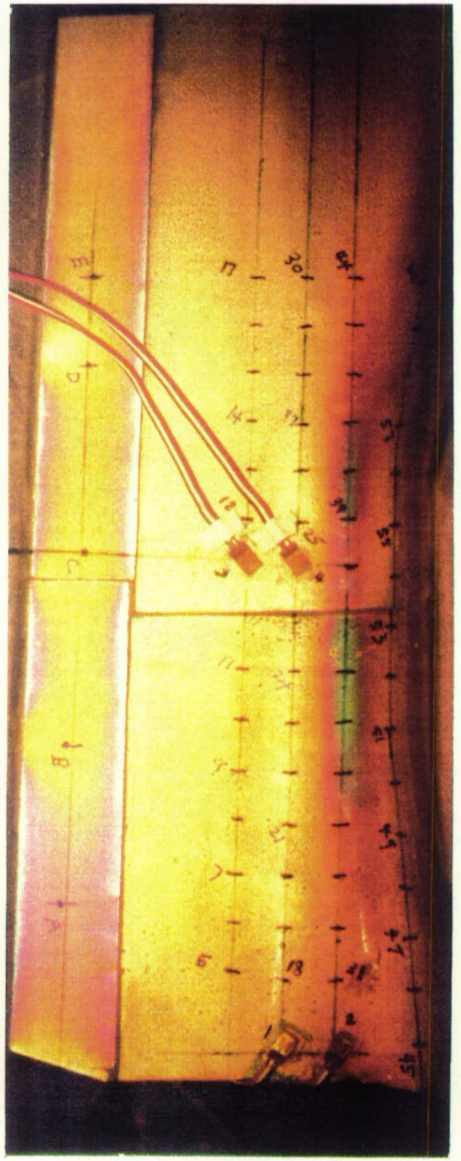
2405 lbs



4810 lbs



7216 lbs



9621 lbs

Photo 4. Fringe Patterns for Applied Loads

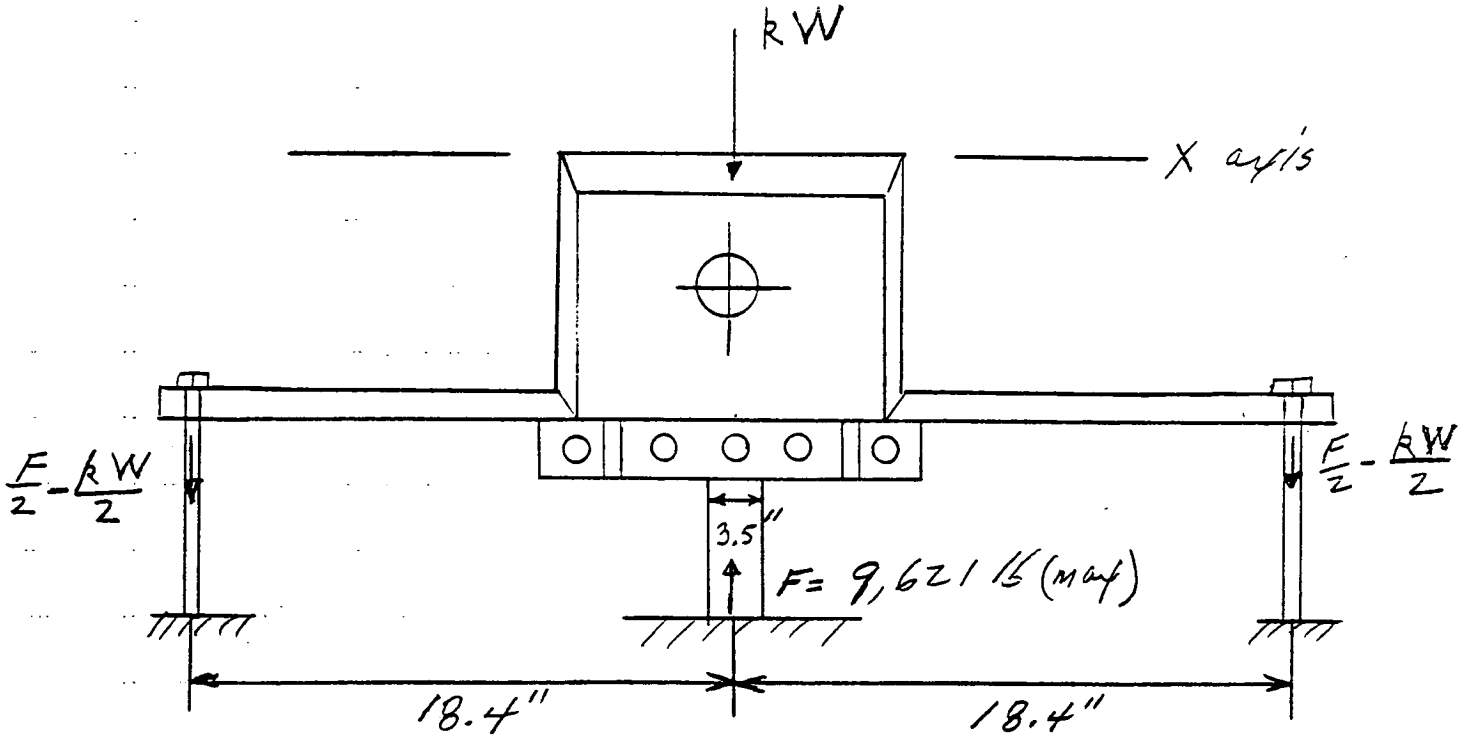


Figure 4. Rear View of Hold-Down Post

the specimen and recording of fringe patterns. No additional work is anticipated until a notice of shipment of the aft skirt test specimen is received.

REFERENCES

1. Gambrell, S. C., Jr., "Use of Photostress to Characterize the Mechanical Behavior of Weldments," Summary of Work, NASA/ASEE Summer Fellowship Program, Metallurgy Research Branch, Metallic Materials Division, Materials and Processes Laboratory, MSFC, May 28 - August 2, 1991.
2. Gambrell, S. C., Jr., "Use of Photostress to Characterize the Mechanical Behavior of Weldments," Final Report, Contract No. NAG8-212, SUB92-195, University of Alabama in Huntsville/NASA, BER Report No. 570-97, September, 1992.
3. Nigam, R. K., "Aft Skirt Weld Factor of Safety Improvement Project-Photostress Evaluation Requirements for AFT Skirt Test Article No. 4," USBI-ANAL-263-93, February 1993.